

Effects of water temperature on early life stages of freshwater mussels: Implications for effluent criteria and climate change

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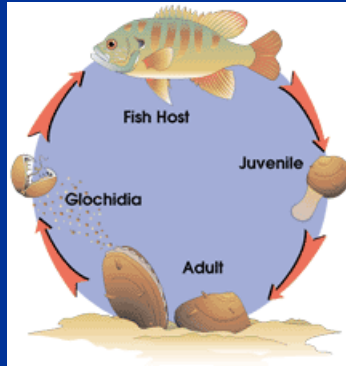
Introduction

- Freshwater mussels are long-lived, benthic aquatic organisms
- One of the most rapidly declining faunal groups in North America
- About 70% of North America's nearly 300 freshwater mussel species are extinct or vulnerable to extinction



Introduction

- Unique life history and reproductive strategy makes them susceptible to chemical and non-chemical stressors



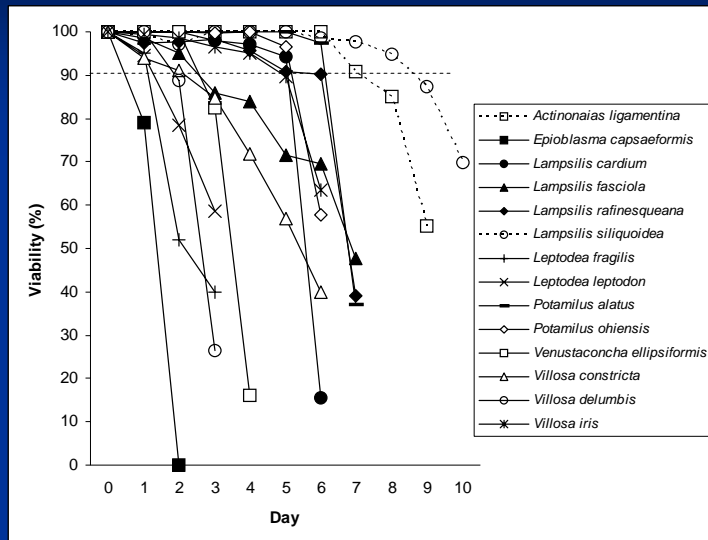
Introduction



- Data gaps exist regarding the effects of non-chemical stressors, such as temperature, on freshwater mussels
- Heated effluent and rising environmental temperatures may pose a risk

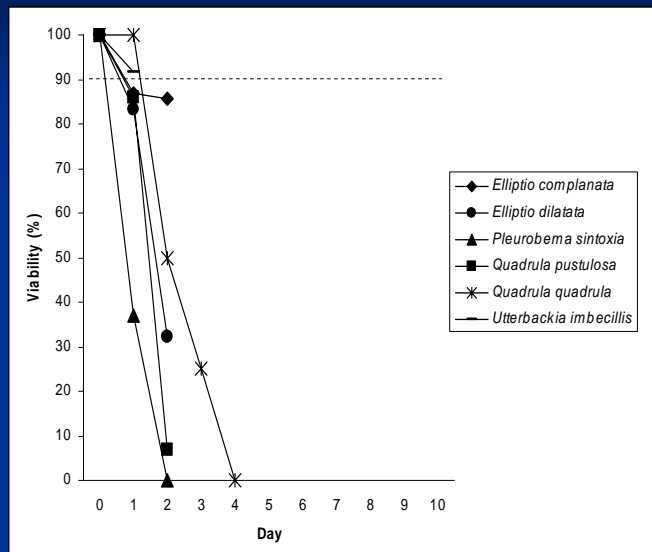


Glochidial Viability Tribe Lampsilini



(Cope et al., 2008)

Glochidial Viability Tribes Pleurobemini, Quadrulini, Anodontini



(Cope et al., 2008)

Glochidial Survival

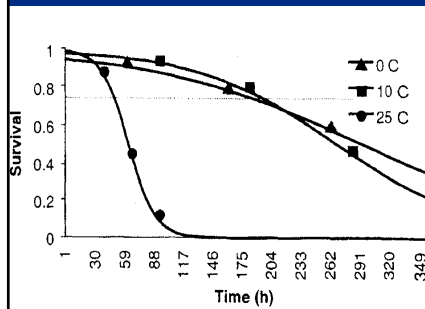


Fig. 1. Model-generated survivorship curves for the extracted glochidia of *Villosa iris*. Dashed line indicates 75% viability.

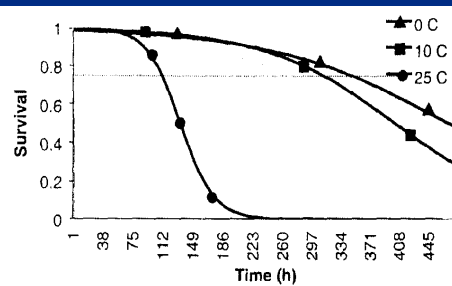
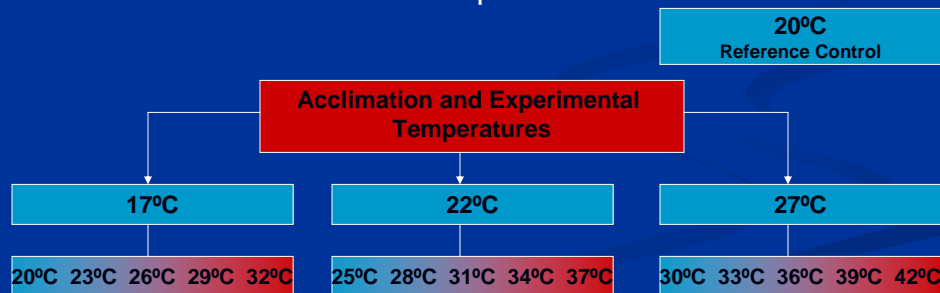


Fig. 3. Model-generated survivorship curves for the extracted glochidia of *Actinonaias pectorosa*. Dashed line indicates 75% viability.

(Zimmerman and Neves, 2002)

Experimental Design

- Two life stages of several different species
- Range of common and extreme water temperatures
- Three acclimation temperatures, with five experimental temperatures for each acclimation
- One reference control temperature



- *Lampsilis siliquioidea*
Fatmucket



- *Potamilus alatus*
Pink Heelsplitter



- *Ligumia recta*
Black Sandshell



- *Megaloniaias nervosa*
Washboard



- *Ellipsaria lineolata*
Butterfly

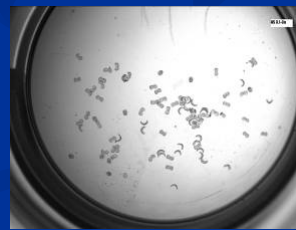


- *Lasmigona complanata*
White Heelsplitter



Experimental Methods

- Glochidia
 - Fatmucket, Pink Heelsplitter, Black Sandshell, Washboard, Butterfly, White Heelsplitter
 - Viability
 - Acclimation
 - 24 hour experiments, ASTM guidelines
 - Endpoint: survival



Experimental Methods

■ Juvenile

- Fatmucket, Pink Heelsplitter, Black Sandshell, Washboard
- Viability
- Acclimation
- 96 hour experiments, ASTM guidelines
- Endpoint: survival



Experimental Methods

- All tests conducted in light and temperature controlled environmental chambers
- Test organisms transported from propagation facility at MSU in insulated coolers with temperature loggers to record temperature
- Mussel viability assessed upon arrival in laboratory

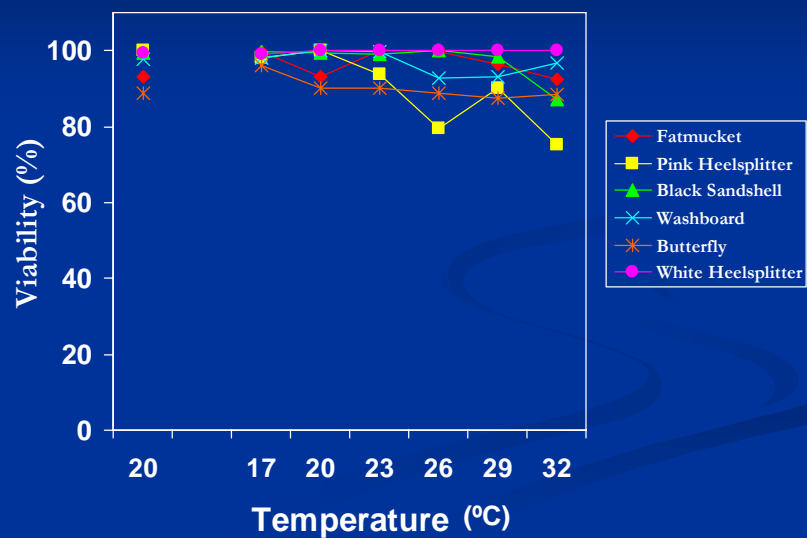


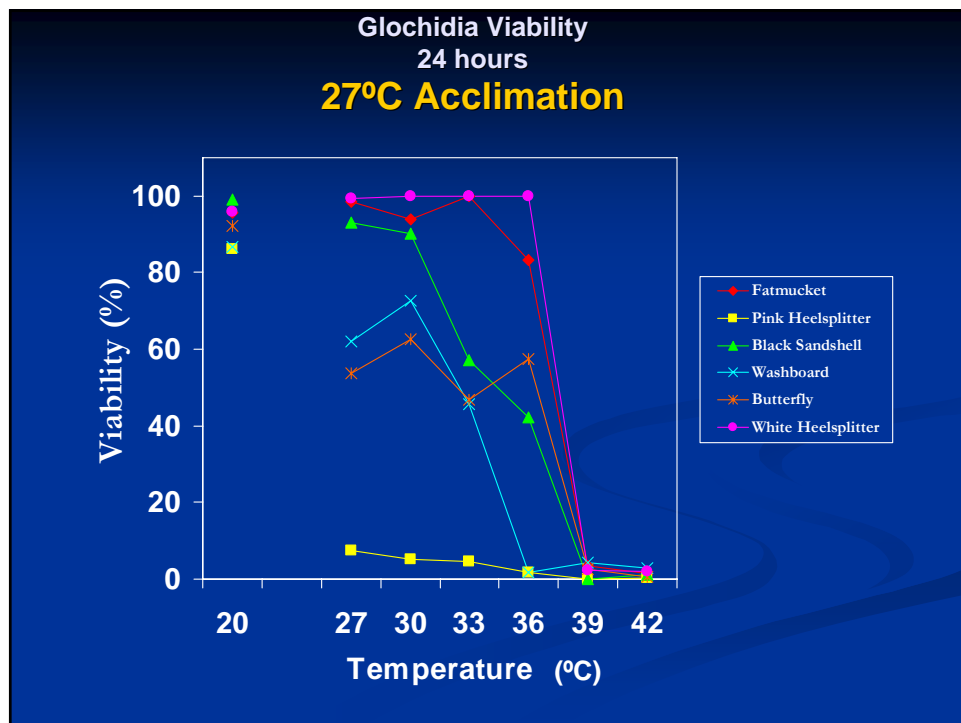
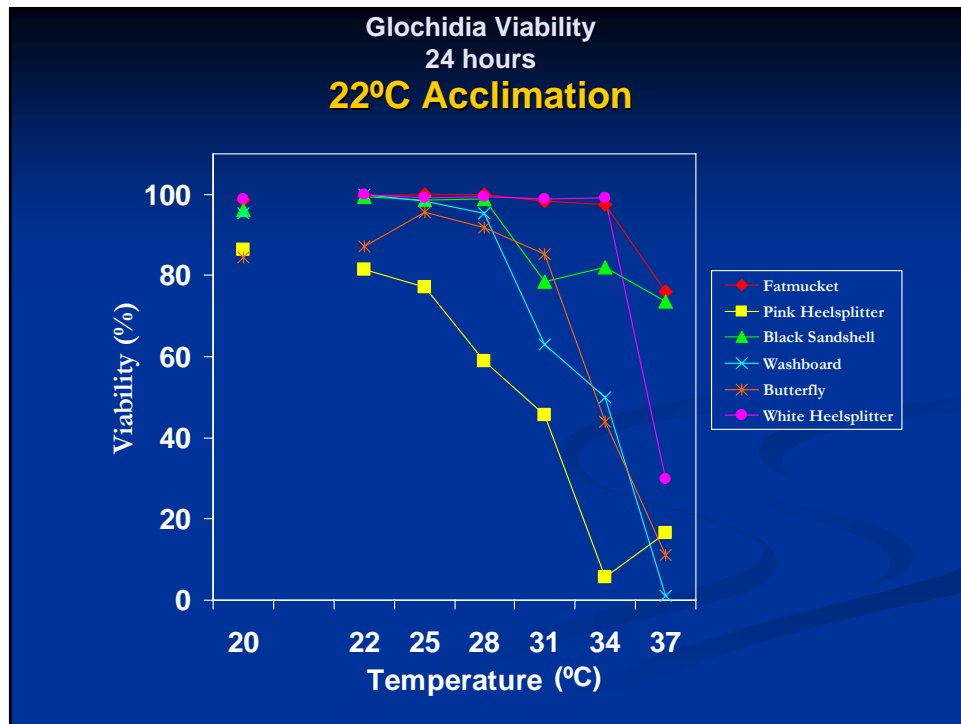
Quality Assurance

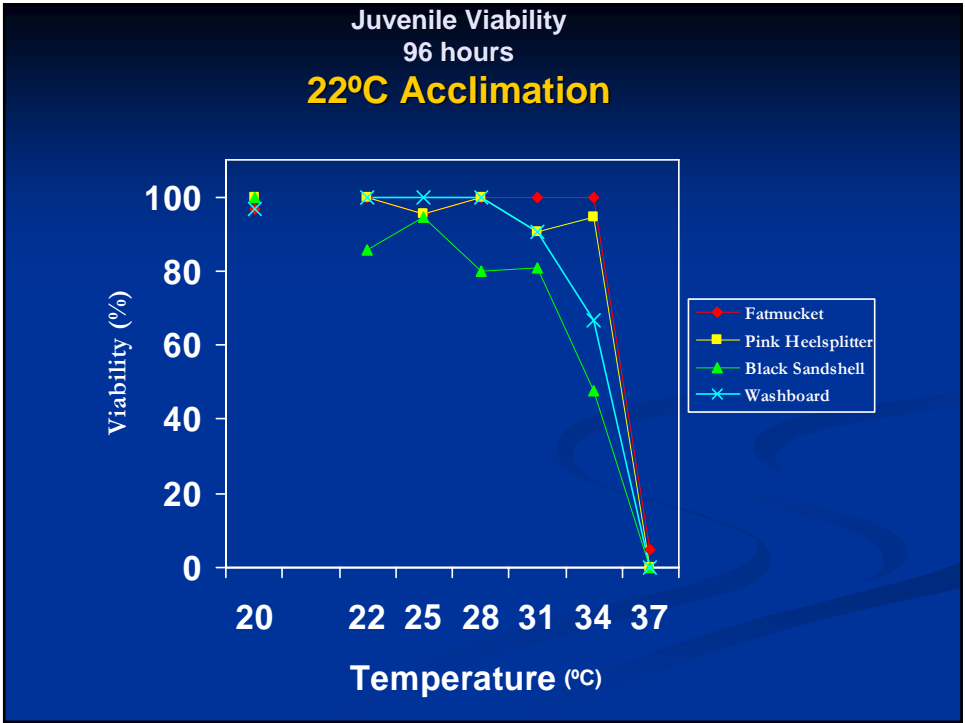
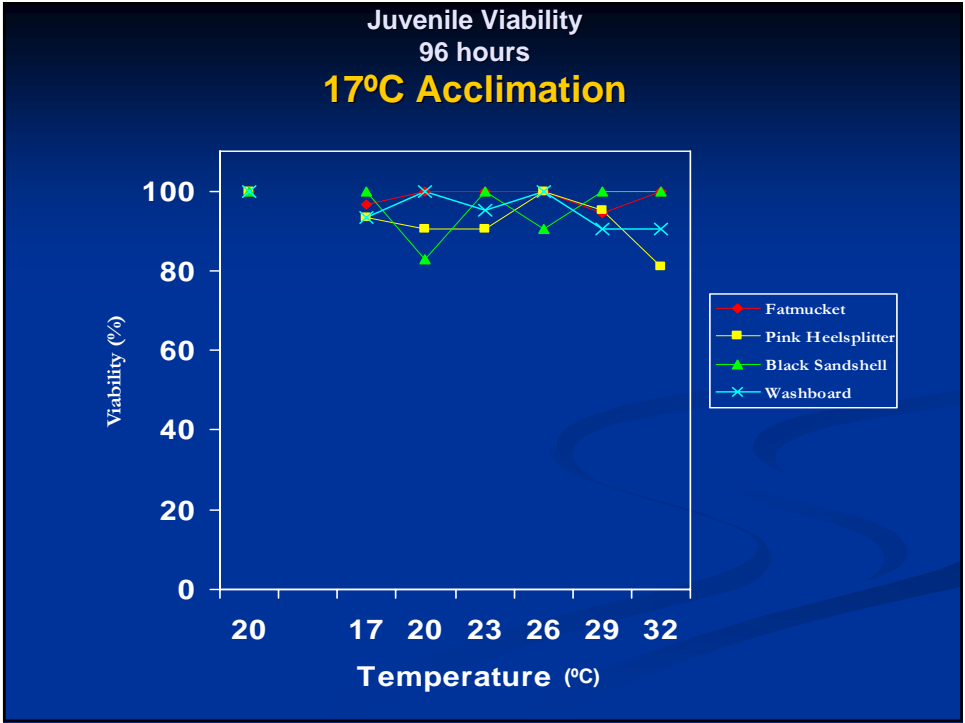
- All tests conducted according to the *Standard Guide for Conducting Laboratory Toxicity Tests with Freshwater Mussels* (ASTM E2455 – 06)
- Water quality conditions monitored
 - alkalinity, hardness, conductivity, temperature, pH, and dissolved oxygen
- NIST certified thermometers for daily temperature monitoring

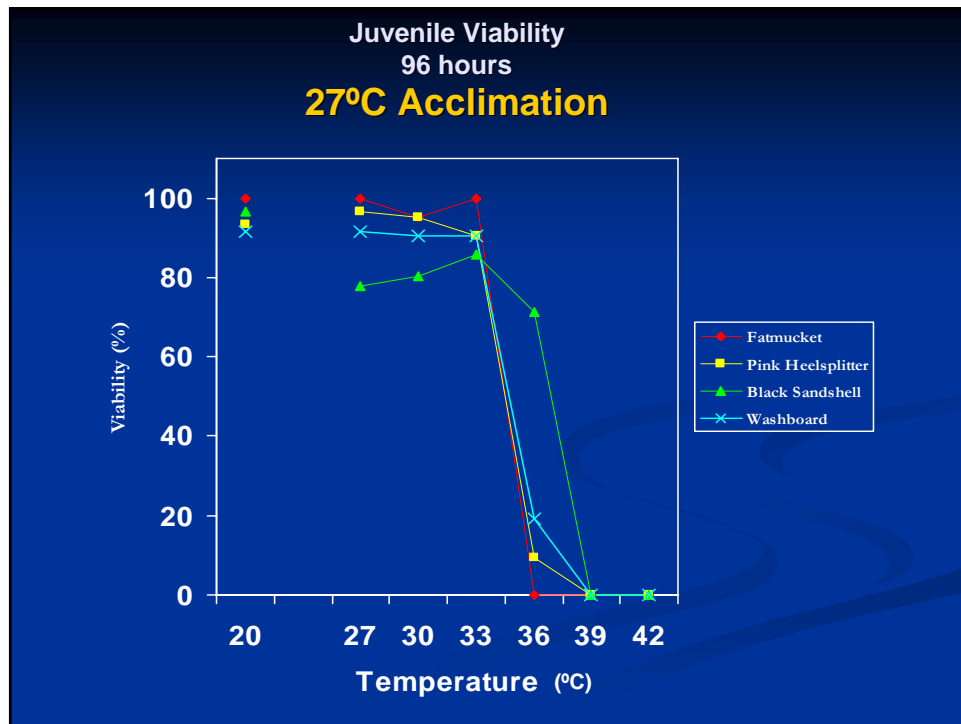


Glochidia Viability
24 hours
17°C Acclimation









ET50s

- Temperature that elicits a predefined effect in 50% of the exposed population
- Effects measured as:
 - Glochidia—viability, indicated by shell closure
 - Juvenile—viability, indicated by presence of heart beat, foot movement within shell, foot movement outside shell

Glochidia 24h ET50s

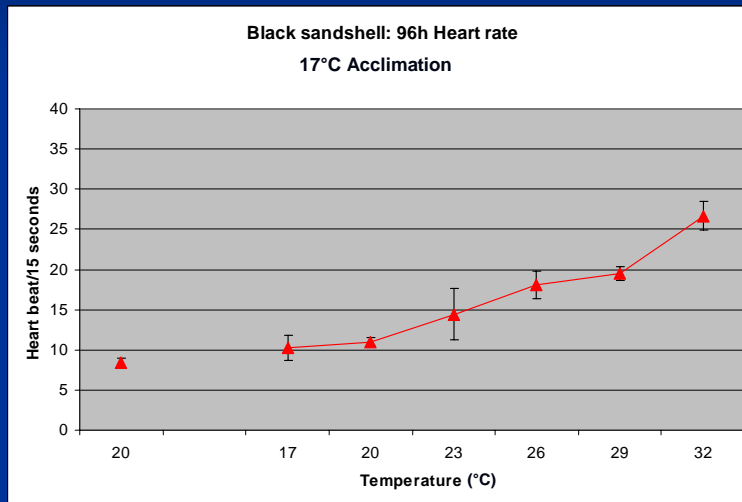
Species	22°C Acclimation	27°C Acclimation
Fatmucket	>37.0	36.9 (35.3-38.6)
Pink Heelsplitter	29.1 (25.6-33.1)	<27.0
Black Sandshell	>37.0	33.9 (30.4-37.8)
Washboard	32.4 (29.6-35.5)	32.4 (29.2-36.0)
Butterfly	33.7 (31.2-36.3)	ND
White Heelsplitter	36.0 (34.3-37.8)	37.5 (36.9-38.1)

Juvenile 96h ET50s

Species	22°C Acclimation	27°C Acclimation
Fatmucket	35.5 (35.1-36.0)	34.3 (33.5-35.1)
Pink Heelsplitter	34.8 (33.1-36.5)	34.6 (33.4-35.9)
Black Sandshell	32.9 (29.6-36.6)	36.7 (34.4-39.3)
Washboard	34.2 (32.3-36.2)	35.2 (33.8-36.7)

Heart Rate Assessment

- Sub lethal measure of thermal stress
- Increases with increasing temperatures



Conclusions

- Environmentally relevant temperatures can adversely affect freshwater mussels
- ET50s were similar for juveniles among species and acclimation temperature, some differences among glochidia
- Average threshold temperature of 31.0°C; compares with overall mean ET50 of 34.4°C

Implications

- Test organisms were sufficiently sensitive to warrant further investigation of criteria protective of freshwater mussels
- Understanding of potential effects of heated effluents and global climate change on freshwater mussels



Future Work

- Species, life stage, temperature comparisons
- Additional species
- Sublethal measurements
 - Heart rate
 - Biomarkers
- Field studies



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